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# **Collider-Accelerator Department Overview**

**Presented to**

**RHIC Facility Annual Science and Technology Review**

**Derek I. Lowenstein  
July 24, 2006**

# **FY2005 Nuclear Physics S&T Review Action Item**

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## **Recommendation**

- BNL is expected to choose between magnetized and non-magnetized cooling around the end of the 2005 calendar year. At that time, a detailed technical review of a documented R&D plan should be conducted to examine the adopted solution, costing estimates, and the further milestones required to demonstrate feasibility.

**Selection of non-magnetized cooling was finalized in December 2005.**

**RHIC Machine Advisory Committee, with DOE observers, reviewed the BNL decision (February 2006) and concurred with the approach. Collaboration meeting (May 2006) reviewed critical physics issues. See Ben-Zvi presentation.**

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## COLLIDER-ACCELERATOR DEPARTMENT

Circa July 2006

**Mission:** “To develop, improve and operate the suite of particle/heavy ion accelerators used to carry out the program of accelerator-based experiments at BNL; support of the experimental program including design, construction and operation of the beam transports to the experiments, plus support of detector and research needs of the experiments; to design and construct new accelerator facilities in support of the BNL and national missions. The C-A Department supports an international user community of over 1500 scientists. The Department performs all these functions in an environmentally responsible and safe manner under a rigorous conduct of operations approach.”

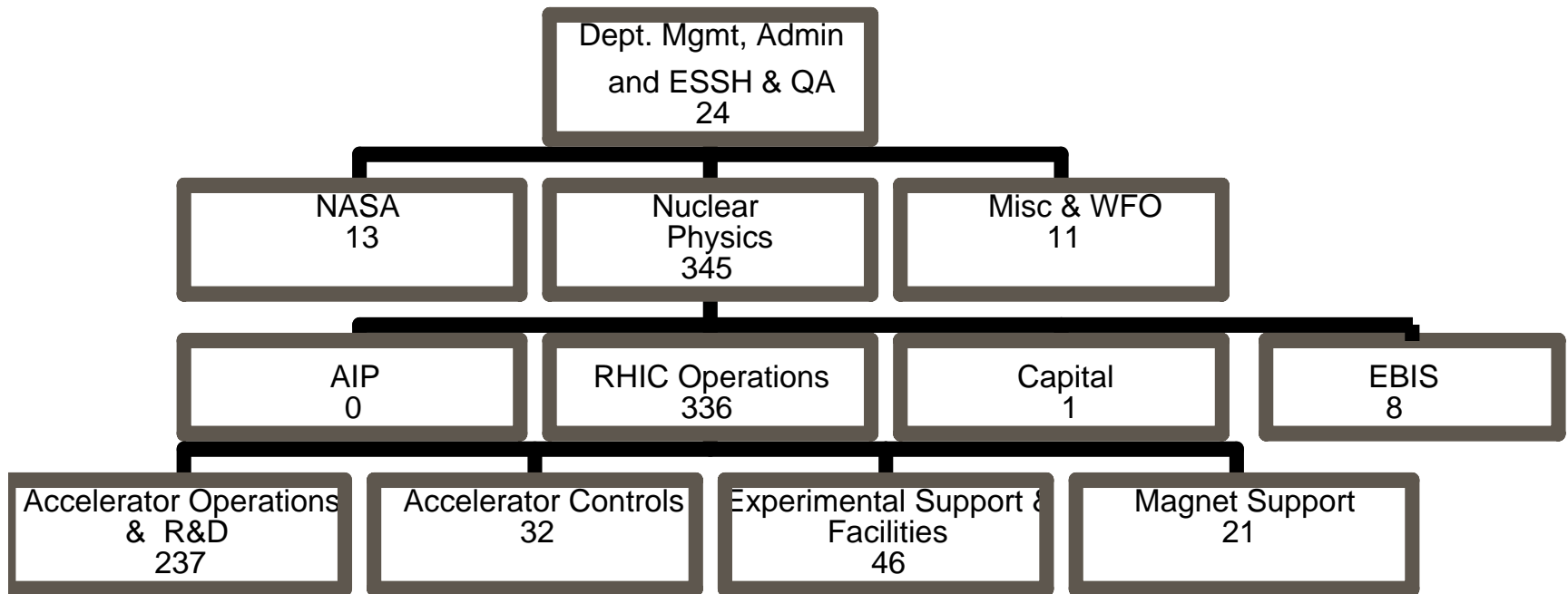
**Staff:** The Collider-Accelerator Department headcount is:

	<u>Total</u>	<u>NP*/ SBF</u>	<u>EBIS</u>	<u>NSRL</u>	<u>Other</u>
Ph.D. Scientists	49	44	1	2	2
Postdoctoral Fellows	1	1	0	0	0
Engineers/Professional	128	116	4	4	4
Designers/Technicians	175	161	3	6	5
Admin./Clerical	<u>19</u>	<u>18</u>	<u>0</u>	<u>1</u>	<u>0</u>
Totals	372	340	8	13	11

\*Does not include ~21 Magnet Division employees charged to NP.  
Additional support ~11 FTEs are purchased as Laboratory assigned trades.

# Collider - Accelerator Department

(Programmatic Heads 393)\*



- Reflects Head data circa June 2006
- 25 FTE reduction from June 2005

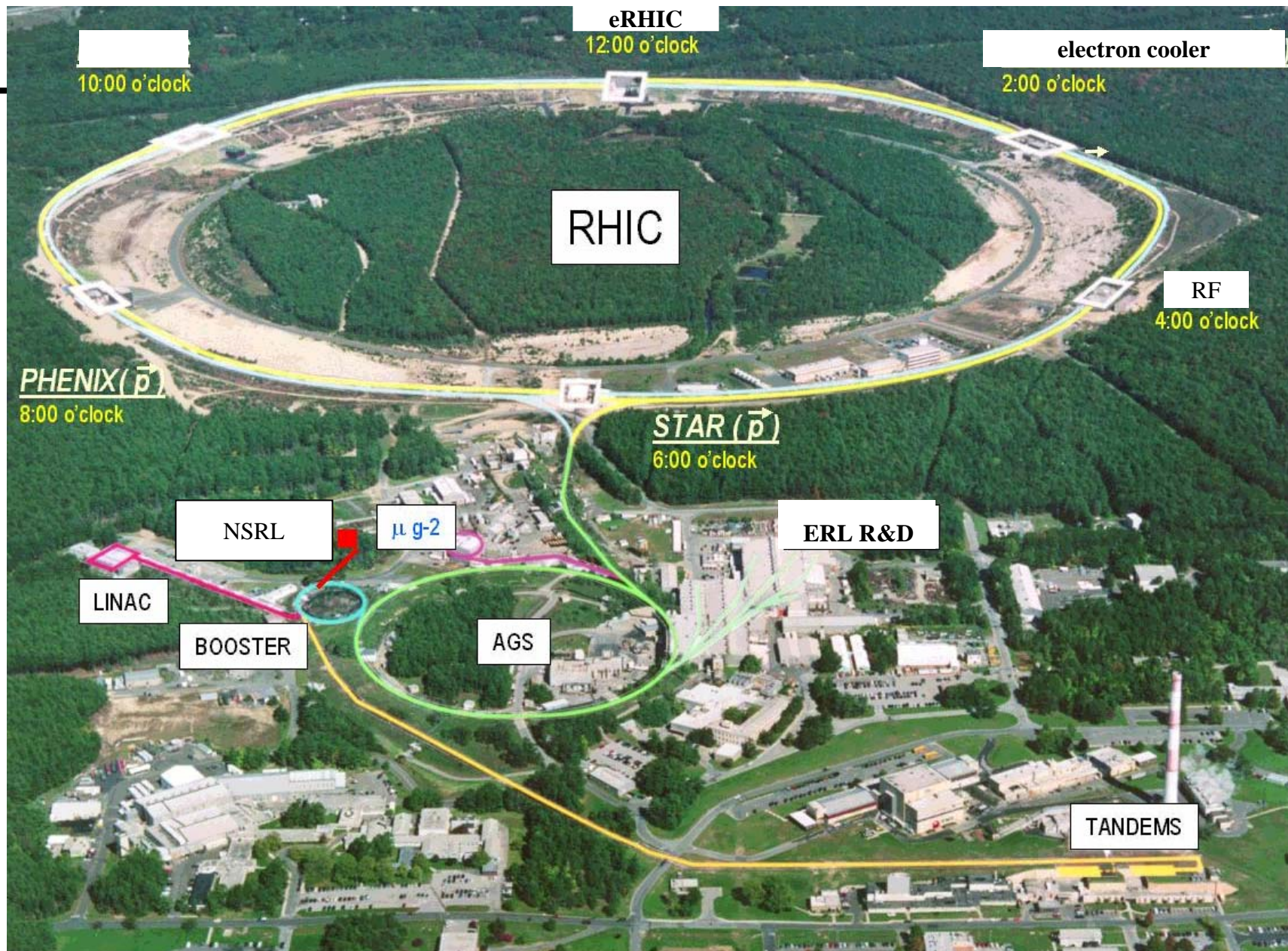
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**FY2006 (to date)**

**Funding:**

<u>Fund Type</u>	<u>DOE NP</u>	<u>SBF</u>	<u>EBIS</u>	<u>NSRL</u>	<u>Other</u>	<u>Totals</u>
DOE Operating	91.7	0.0	.1	0.0	.7	92.5
DOE Equipment	.7	0.0	0.0	0.0	0.0	.7
DOE Construction/AIP	1.5	0.0	2.0	0.0	0.0	3.5
WFO	0.0	12.0	0.0	0.0	6.7	18.7
NASA	<u>0.0</u>	<u>0.0</u>	<u>.5</u>	<u>3.9</u>	<u>0.0</u>	<u>5.4</u>
Totals	93.9	12.0	3.6	3.9	7.4	120.8





# **FY 2006 Awards and Publications**

## **FY 2006 Awards (to date)**

- **BNL Science & Technology Award – J. Alessi, January 2006**
- **BNL Engineering Award – J. Sandberg, January 2006**
- **BNL Brookhaven Award – R. Karol, January 2006**
- **BNL Environmental Stewardship Award – V. LoDestro, B. Briscoe, W. Shaffer, April 2006**
- **Russian Academy of Sciences Veksler Award – A. Zelenski, April 2006**
- **NPSS IEEE Graduate Scholarship Award – R. Calaga, Nov. 2005**
- **Stony Brook University President's Award for Distinguished Doctoral Students – R. Calaga, May 2006**
- **2006 Faraday Cup Award - H. Huang**

## **FY 2006 Publications and invited talks (to date)**

- **218 publications**
  - **35 journal, 22 refereed**
  - **182 conference proceedings**
  - **1 report**
- **Approx. 10 invited talks**

# C-AD Accelerator Community Leadership Positions

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- President, Particle Accelerator S&T, IEEE NPSS; I. Ben Zvi
- USPAS Program Advisory Committee: V. Litvinenko
  - APS DPB Nominating Committee
- Chair, US Particle Accelerator School Board of Governors: D. Lowenstein
- Program Leader, US LARP: S. Peggs
- Member, APS DPB Nominating Committee: F. Pilat
- Chair, APS Division of Particles & Beams Executive Comm.: T. Roser
- Editor, ICFA Beam Dynamics Newsletter: J. Wei
- + others serving on DOE, NNSA, NSF, CERN, UK and GSI committees and reviews



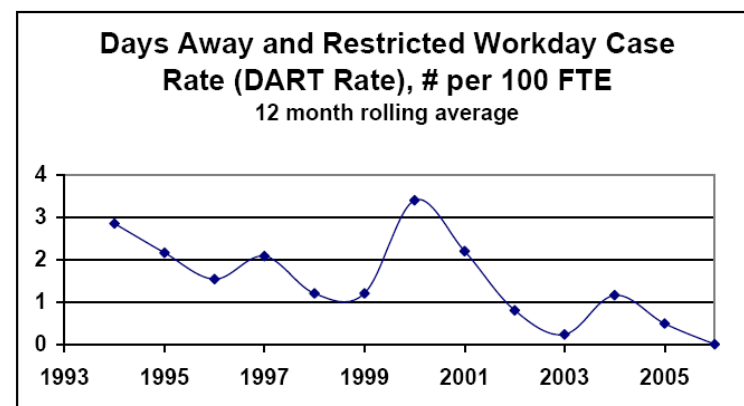
# C-AD ES&H Performance Indicators

	2004	2005	10-1-05 To 6-1-06
Whole-Body Collective Dose (person-rem)	5.28	1.4	0.4
Skin and Clothing Contaminations	0	0	0
Internal Contamination	0	0	0
Radioactive/Hazardous Materials Overexposures	0	0	0
Days Away and Restricted Day Rate (# per 100 FTEs)	1.7	0.29	0
1. Cases	7	1	0
2. Total Hours Worked in Year (1000s)	826	684	434
Recordable Injury/Illness Rate (# per 100 FTEs)	2.9	1.17	1.38
1. Cases	12	4	3
First Aid Cases Excluding Athletic Injuries	5	1	0
Unplanned Safety Function Actuations	0	0	0
Violations of Operating Procedures	0	0	0
Unplanned Shutdowns	0	0	0
Occurrences	7	3	2
Environmental Related Occurrences	0	0	0
Solid Low-Level Waste Shipped			
1. Radioactive Waste (cu-ft)	2400	5100	96
2. Hazardous Waste (cu-ft)	200	117	46.7
3. Mixed Waste (cu-ft)	35	219	7
4. Industrial Waste (cu-ft)	700	615	71.7

## FY06 C-AD Reportable Occurrences

Energized Wire Discovered During RF Amp Repair, 11-3-2005

400 Amp Electrical Switch Failure, 4-14-2006



**564 days without lost work**  
**See E. Lessard presentation**

## FY2006 Budget Recap

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- FY2006 federal budget allowed for only 5-6 weeks of operations and a reduction of personnel. 14 persons were immediately dismissed.
  - Also reduced SMD manpower support from 35 FTE to 21 FTE
- Renaissance Technologies Corp. support, in December 2005, of \$12M (C-AD) allowed for 21 weeks, experiment support and retention of 40 persons
  - Beam availability dropped to 80% from 85%, exacerbated by insufficient manpower to stay ahead of the maintenance curve
- DOE unfunded infrastructure mandate again forced, for the second year, an increased space charge rate at 9.8%
  - Increased space charge reduces available operating funds by \$1M in FY2006, on top of the \$1M in FY2005 and again in FY2007
- New NYPA power rates went into effect in July 2005.
  - Average power rate is volatile and has averaged around \$80+ / MWH, up from \$55 / MWH
- e-cooling R&D limited to \$2M, but augmented by Navy. (see Ben-Zvi talk)
- Climate control infrastructure is now a significant problem area being addressed

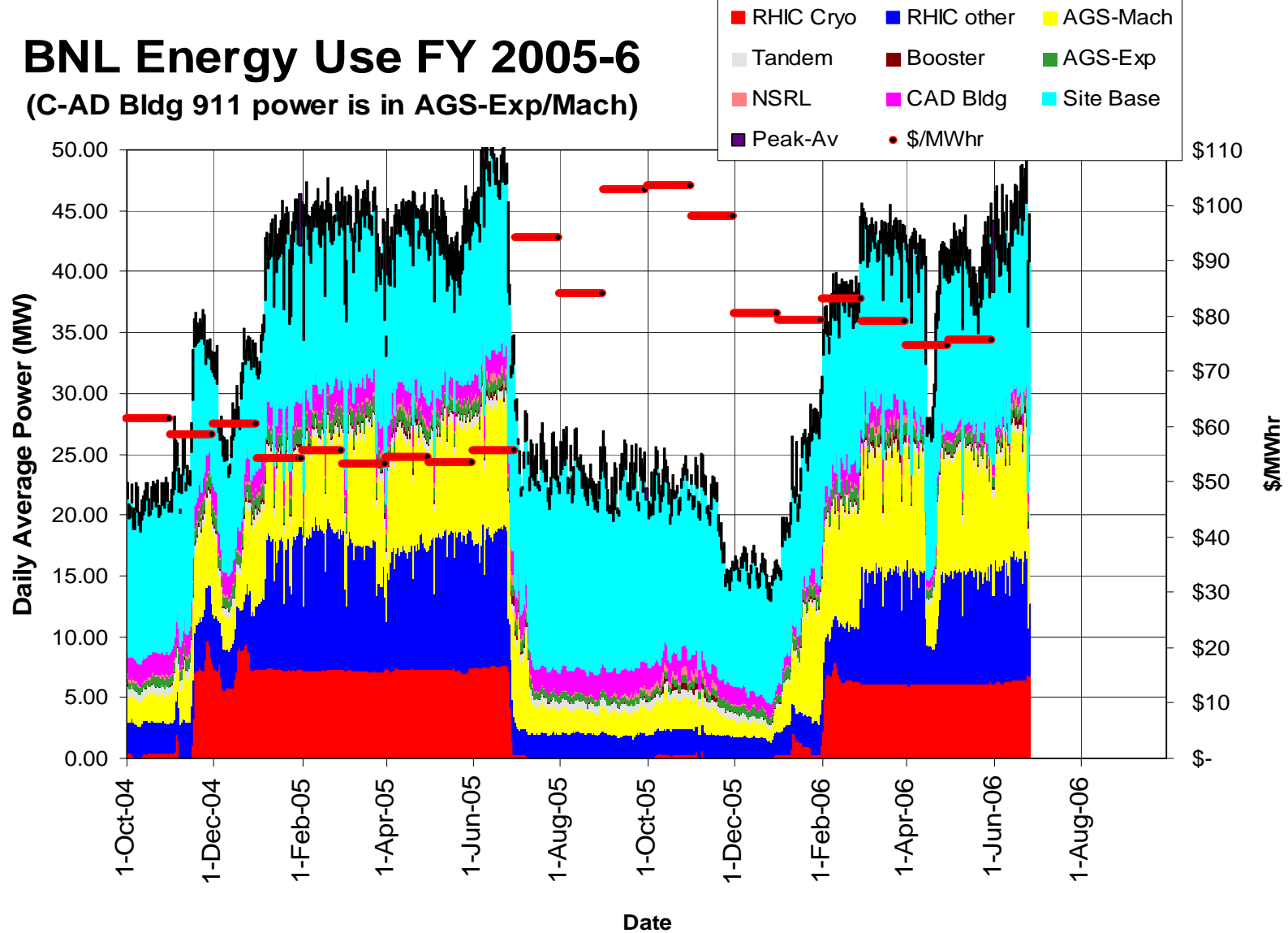
## **FY2006 Cost Changes and Responses**

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- Power rate increase from \$55 to \$80+ / MWH (\$3900K for 21 weeks)
- Space charge (\$1000K increase per year for FY05,06,07))
- Cryogenic system power demand reduced by 1.5 MW in FY06 <\$425K>
- Reduced cooldown time by 2 weeks (+2 physics weeks)
- Reduced operations startup time by 1.5 weeks (+1.5 physics weeks)
- Increased proton luminosity (equivalent to ~10 weeks more luminosity)
- Reduced baseload shutdown power demand by 1.5-3 MW <\$250-500K>
- Reduced C-AD building footprint <\$500K>
- Involuntary reduction of personnel <\$2000K>
- Increased WFO effort; saved 11 persons <\$1200>

# BNL Energy Use FY 2005-6

(C-AD Bldg 911 power is in AGS-Exp/Mach)



# C-AD Program Areas

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## **RHIC**

- Heavy Ion (DOE-NP).
- Polarized Proton (DOE-NP).

## **Tandem**

- Commercial Users (\$1M yearly sales).

## **Linac**

- Isotope Production (DOE-NE)

## **Booster**

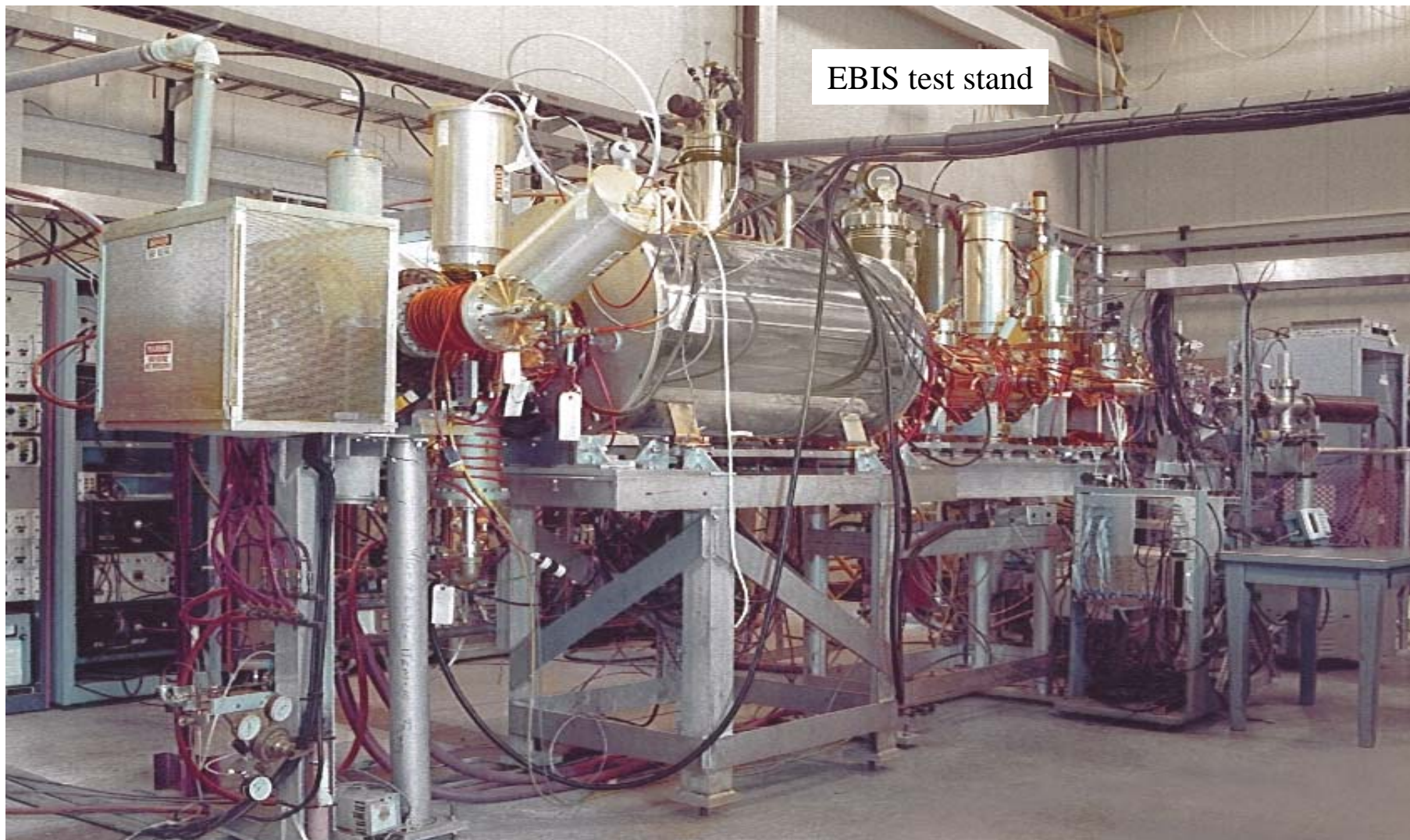
- NASA Space Radiation Laboratory (NASA, \$5.5M/year, +\$2M for Medical and Biology Departments).



## EBIS Project

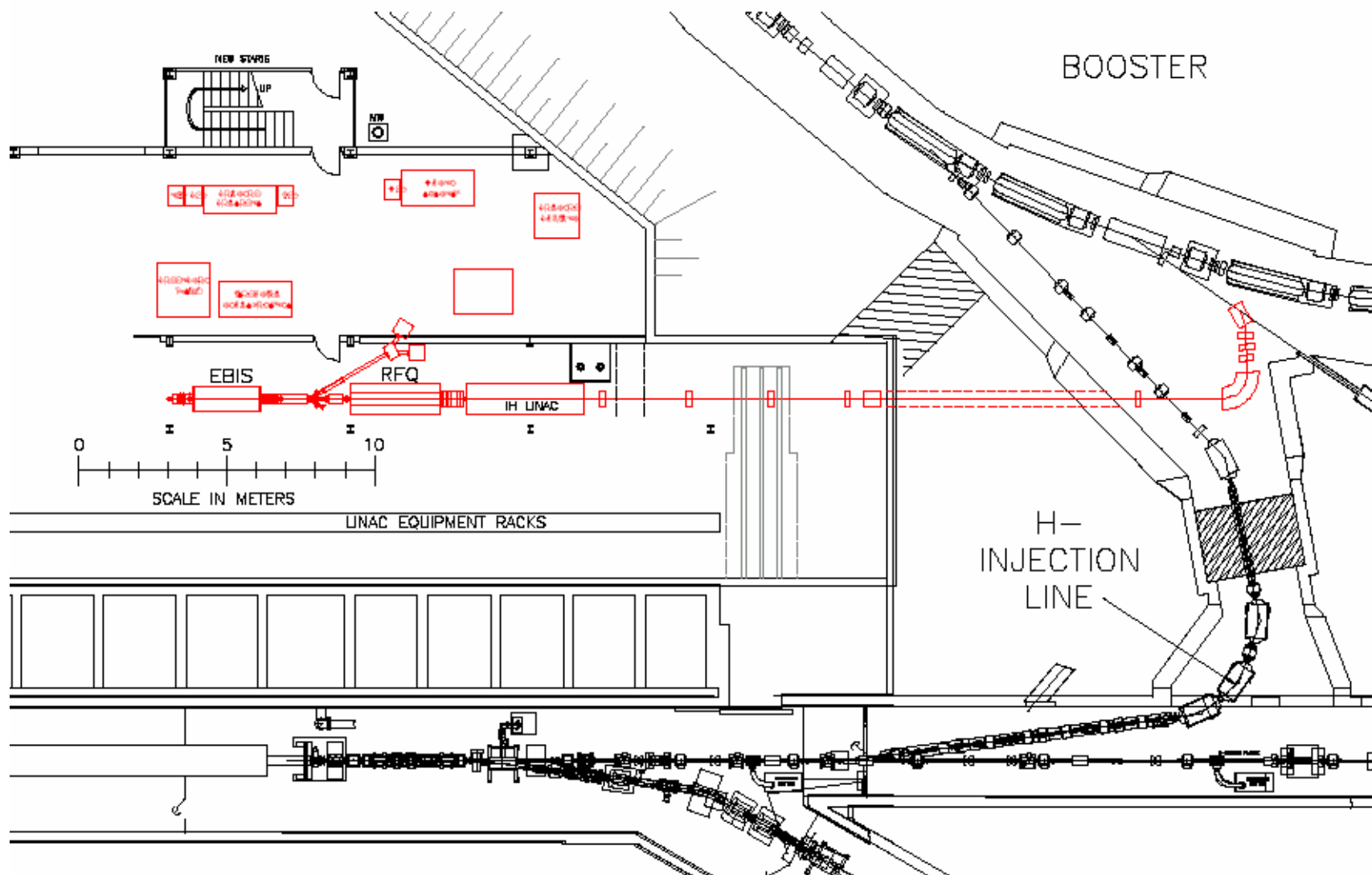
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- Joint DOE and NASA Project
- Goal is to replace tandems
  - Improved beam intensity
  - Allow for masses to uranium and noble gases
  - Lower operating costs
- Second step, CD1 is approved
- Empire State Development Corporation infrastructure support expected in August (\$1.3M)
- Third step, CD2 is expected by autumn 2006.
- Fourth step, CD3, is expected by early FY07
- NASA is providing \$4.5M
  - Agreed upon funding schedule is being executed and construction has begun
- \$19.3M to build EBIS, RFQ and Linac
- Commissioning in FY2009



EBIS test stand

# RHIC EBIS Injector Layout



# Distribution of FY 05-08 Capital Equipment/AIP Funds (\$K)

	FY 05	FY 06	FY 07	FY 08
B&R Code: KB-02-02-01-1	Actual	Actual	Planned	Planned
<b><u>Facility Base Capital Equipment</u></b>	<b><u>\$1,200</u></b>	<b><u>\$611</u></b>	<b><u>\$1,000</u></b>	<b><u>\$1,035</u></b>
AGS Ion Pump Control Upgrade	500		500	
Replace LINAC Cooling Tower (Phase II)	273			
RHIC/AGS Low Level RF Upgrade	200	200	200	
RF Test Equipment	127	191	100	
Upgrade of AGS Ring Fire Alarm System (Phase III)	100			
RHIC Service Building Improvement			200	335
Booster Power Supply Interfaces		120		
LEBT and MEBT Modification for Polarized Protons		100		
Load-Matched Cryo Turbines				600
Siemens Relays Replacement				100
<b><u>AIP</u></b>	<b><u>\$3,100</u></b>	<b><u>\$1,500</u></b>	<b><u>\$2,100</u></b>	<b><u>\$2,174</u></b>
AGS MMPS Transformer Replacement & Ripple Reduction	1,700	1,000	900	
RHIC Cryogenic Cold Turbine Addition	1,000			
RHIC Cold Bore Vacuum Upgrade	400			
RHIC Stochastic Cooling		500	500	
AGS Electrical Infrastructure Replacements			700	674
AGS Roughing Pumps and Vacuum Gauges				500
Westinghouse Motor-Generator Stator Insulation				600
RHIC Cryo Control System Upgrade				400

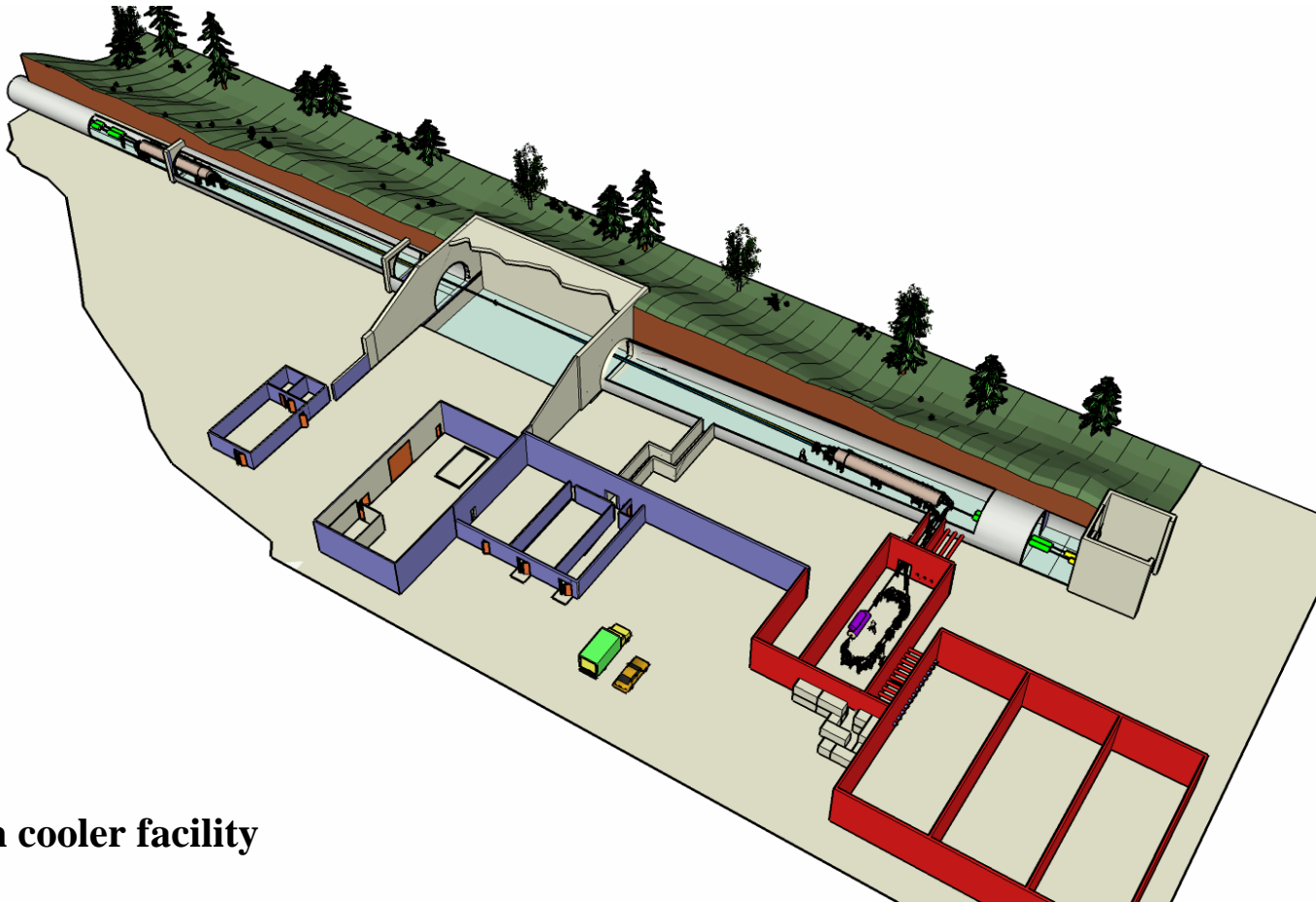
## C-AD Non-NP Program Areas

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- Spallation Neutron Source (DOE-BES, completed, \$118M)
  - Accumulator ring and beam lines: delivered on schedule, below estimated cost **and operates as designed**.
- Proton therapy facility. CRADA to start construction has been signed. BNL design + commercial sector. Funding has been received
- Joint neutrino source R&D effort with FNAL (DOE HEP)
- NSLSII CD1 design (DOE BES)



- electron-cooling of ions(DOE NP, BNL PDF, US Navy, AES, JLab). See Ilan Ben-Zvi presentation
  - Non-magnetized electron beam selected
  - Significant progress over the past year
- stochastic - cooling of RHIC ions. See Mike Brennan presentation.
  - Beam studies have shown first cooling at RHIC (100 GeV)
- eRHIC design (MIT-Bates, Novosibirsk, JLab). See Vladimir Litvinenko presentation
  - 3 designs under consideration. Expect selection within the next 12 months. (ring-ring; linac-ring; linac-ring + positron storage ring)
- Polarized He3 source
  - Expect MIT-Bates, Caltech groups to submit R&D proposal
  - Anatoli Zelenski heads the BNL part of the collaboration



IP2: electron cooler facility

## Accelerator R&D Effort

	FY2005 \$M	FY2006 \$M	FY2007(proj) \$M	FY2008(proj.) \$M
e-cooling (DOE NP) (MS)	2.0	2.0	3.0	1.0
e-cooling (other) (labor,MS)	2.8	4.3	4.6	8.8
stochastic cooling (labor,MS)	0.5	0.5	0.5	
eRHIC (labor)	0.3	0.5	1	3
EBIS (labor, MS)	0.3	0.4		
Machine Operations Development (labor, machine time)	3.8	4	4.1	4.2
FFAG (labor)	<u>0.1</u>	<u>0.1</u>	<u>0.1</u>	
Total (all sources)	10	11.8	13.3	17
Total (DOE NP)	7.2	7.5	8.7	8.2

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# RHIC Performance

# RHIC: unlike any other collider

1. Greater operational flexibility than other hadron colliders
  - Variation in particle species, also asymmetric  
→ So far Au+Au, Cu+Cu, d+Au,  $p\uparrow + p\uparrow$
  - Variation in beam energy  
→ Au+Au at 10, 28, 31, 66, 100 GeV/u  
→ Cu+Cu 11, 31, 100 GeV/u  
→  $p\uparrow + p\uparrow$  at 100 GeV, 31 GeV
    - Commissioned  $p\uparrow$  at 205 and 250 GeV
    - Low energy  $p\uparrow$  22.5 GeV commissioning, equiv. 9.2 GeV Au x Au
  - Variation in lattice  
→ Low  $\beta^*$  in most cases (.85-3 m)  
→ Large  $\beta^*$  for small angle scattering experiments (>10 m)  
→ Polarity change in some experimental magnets
  - Polarization, variable orientations and polarization patterns
2. Five experiments (2 large, 3 small ones now complete), different preferences
  - Need to avoid that any one experiment becomes bottleneck
3. Short runs (20-30 weeks/year), with multiple modes
  - set-up overhead time constantly being reduced
4. Short luminosity lifetime with heavy ions (~ few hours)
  - Fast refills essential



# **RHIC pp** -see Thomas Roser presentation

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100 x 100 GeV for experiments PHENIX and STAR

- Greatly improved luminosity and polarization performance
- Provided longitudinal and transversely polarized beam
- Superconducting partial Siberian Snake in AGS was made operational
- Accelerated/collided 111x111 bunches @  $1.4 \times 10^{11}$  per bunch from the previous 111x111 @  $.75 \times 10^{11}$  per bunch

31.2 x 31.2 GeV for experiments BRAHMS, PHENIX and STAR

- BRAHMS experiment ended

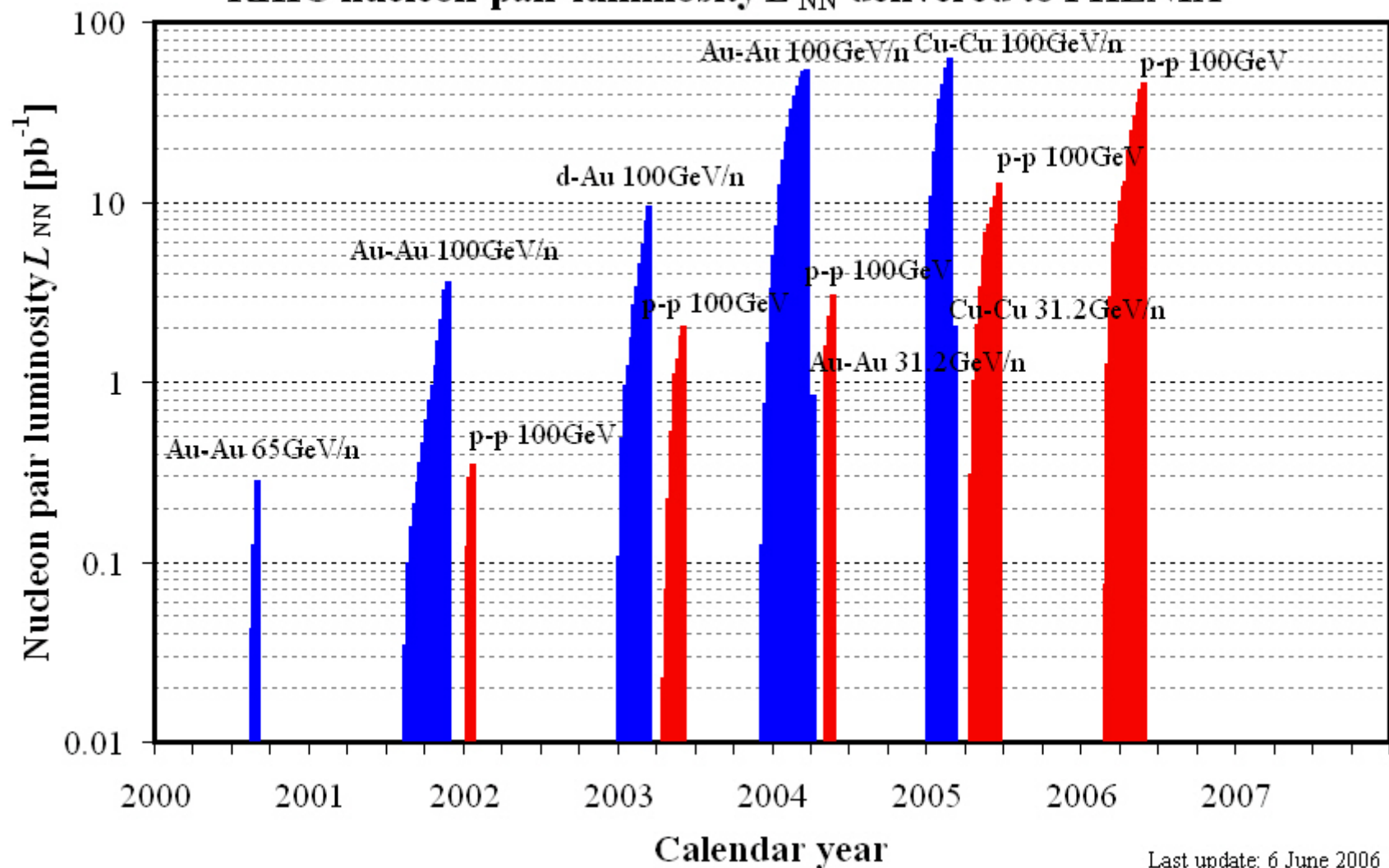
Low energy operations

- Successfully tested RHIC at 22 GeV protons equivalent to 9 GeV Au x Au

Beyond 100 GeV

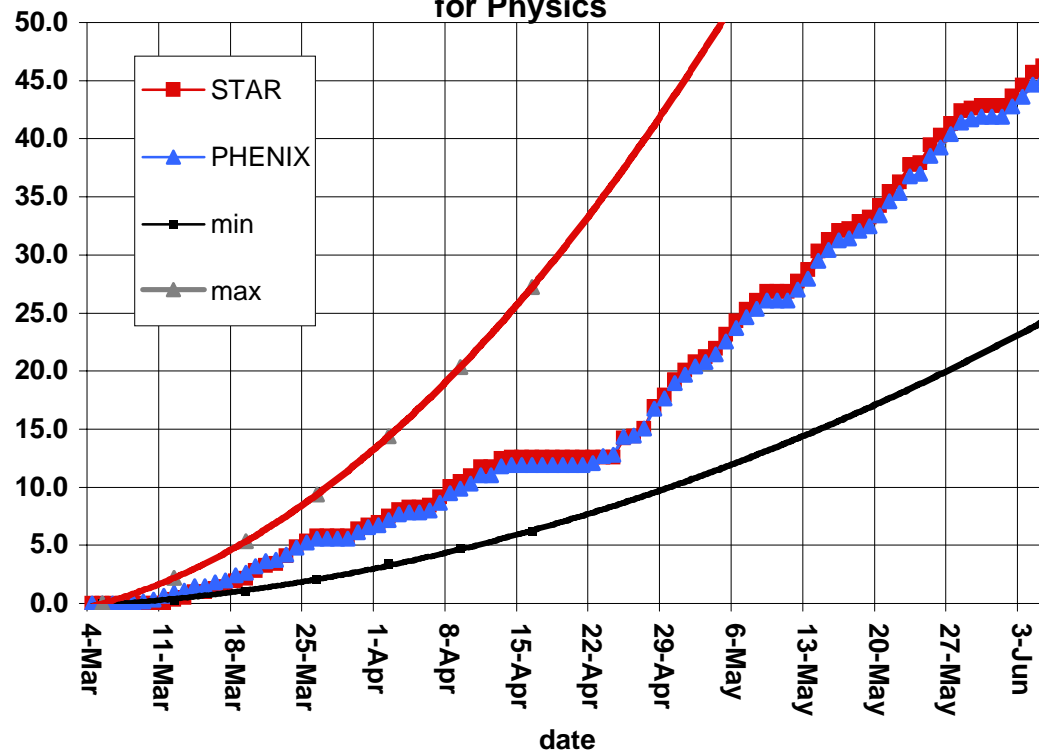
- Beam was accelerated to 250 GeV in preparation for experiment requests
  - ~50% polarization (Blue ring)

# RHIC nucleon-pair luminosity $L_{NN}$ delivered to PHENIX

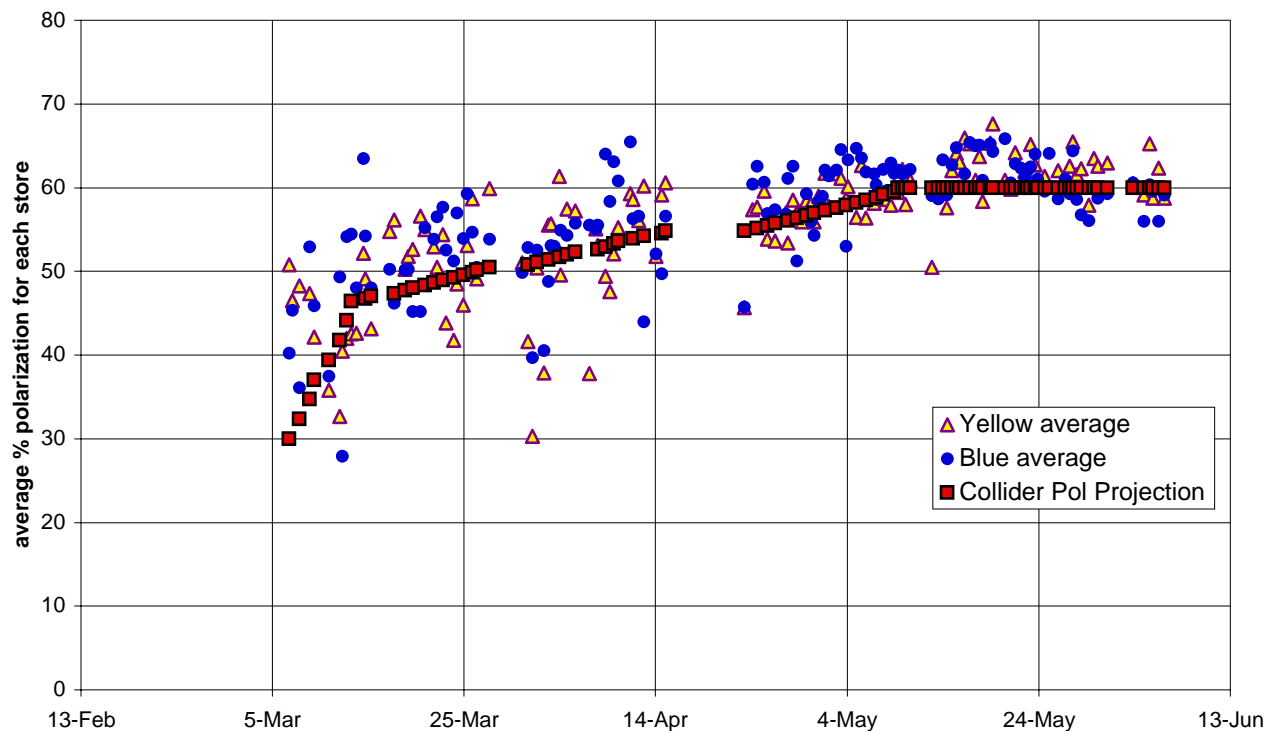


Last update: 6 June 2006

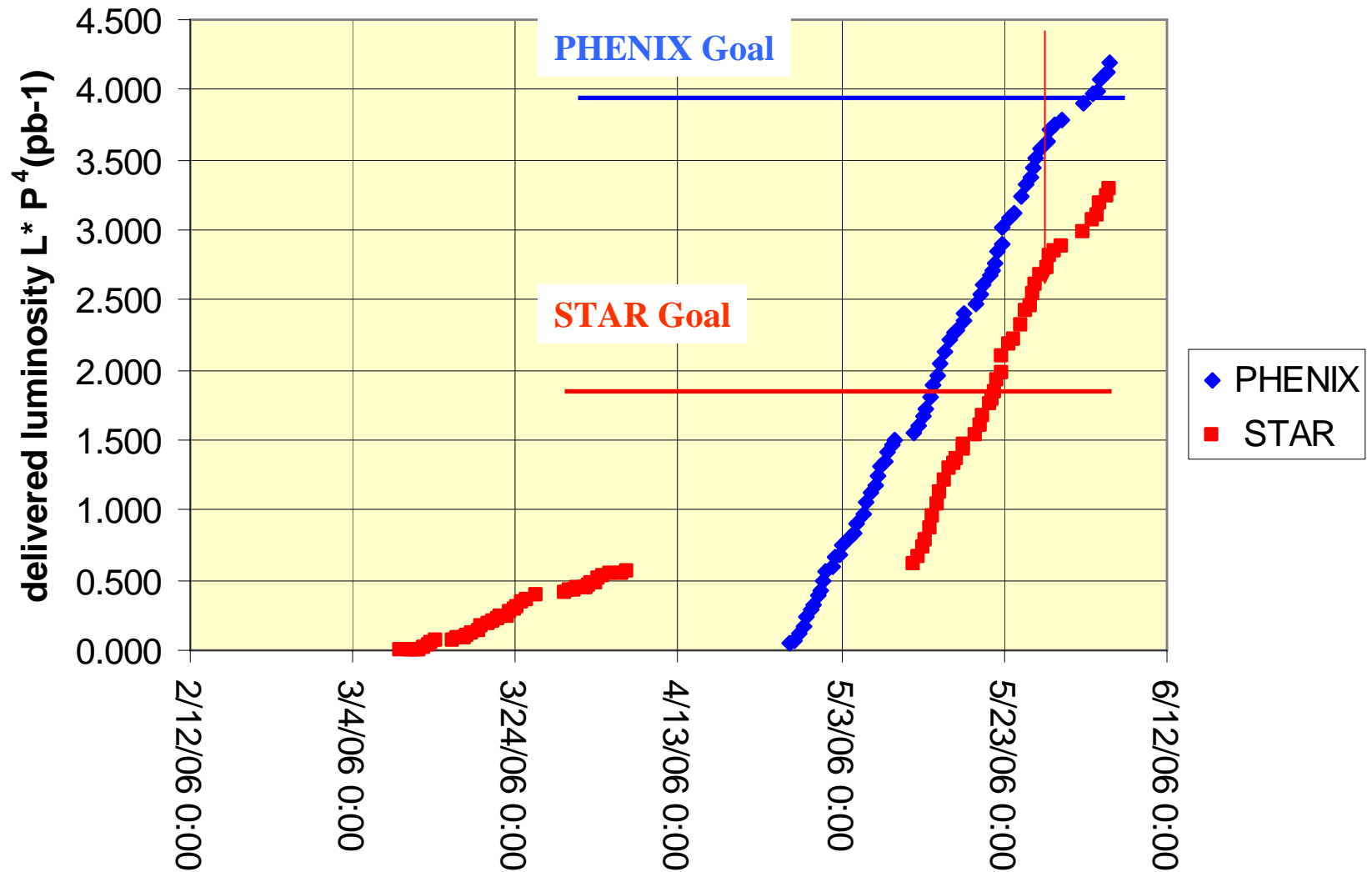
Run6 100 x 100 GeV pp Integrated Luminosity (Final Delivered)  
for Physics



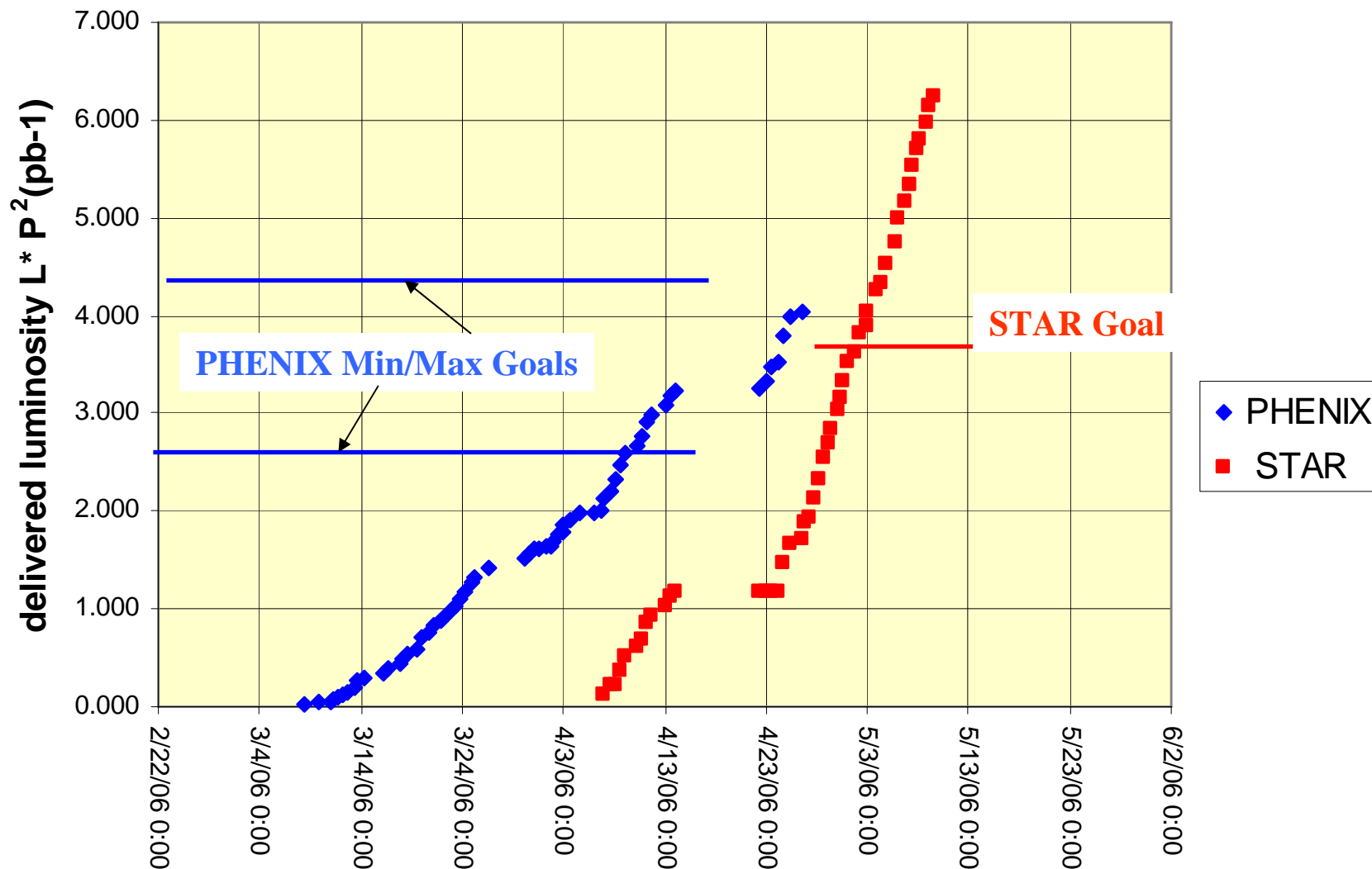
## polarization for Run 6, 100x 100 GeV - final



# 100 x 100 GeV pp RUN-6 final integrated Luminosity for Longitudinal Polarization ( $P^4L$ )



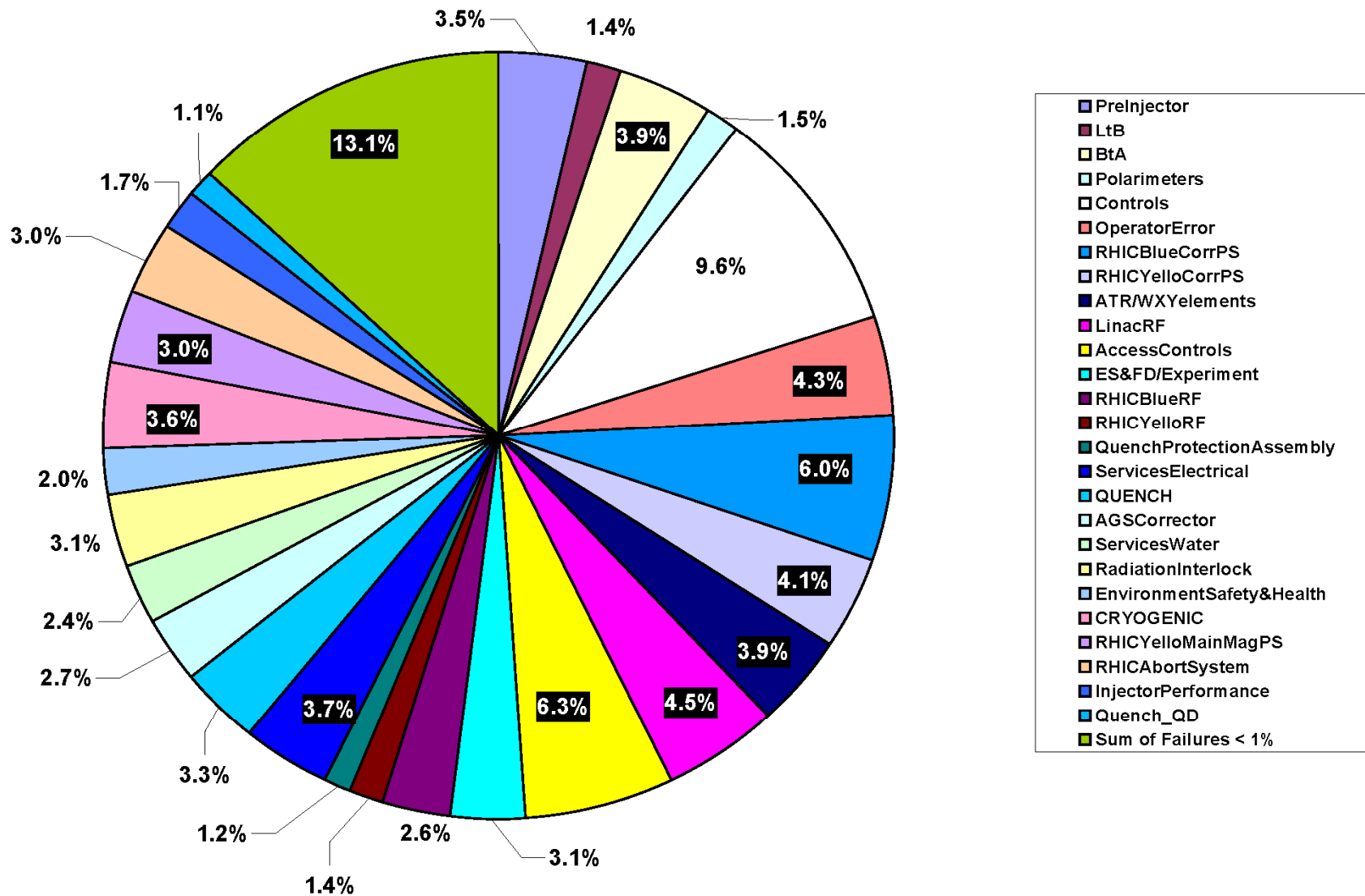
# 100 x 100 GeV pp RUN-6 integrated Luminosity for Transverse/Radial Polarization ( $P^2L$ ) - final





## RHIC Run6 System Failures as a fraction of the Total 699 failure hours

### Availability challenge



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## **FY2006 RHIC operations was again outstanding**

despite the disruptive fiscal problem and  
extraordinary funding relief

# C-AD Energy Use FY 2002-6

(C-AD bldg 911 power is in AGS-Exp/Mach, other bldg power not included)

